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Teaching Database Systems at the Faculty of Informatics at the University of Debrecen

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Abstract

The Bologna system has been introduced at the Faculty of Informatics at the University of Debrecen by the launch of the Software Engineering BSc major. The first students of this major graduated in 2007. The Software Engineering MSc major started in the same year, and the first MSc students graduated in 2009. Based on the experience of the first BSc major, the system of subjects and knowledges has been revised.

In the bachelor's program, the discipline of Database Systems is represented by two compulsory subjects and one elective subject block. In the master's program one subject is compulsory. Additionally, in two specializations further elective subjects are at the students' disposal.

In this paper, we present the state and teaching experience of database knowledge in the frame of the Software Enginnering BSc and MSc programs. We also respect some didactic questions.

Keywords: Database systems, subjects, curriculum.

MSC: 97Q99

1. Introduction

The Software Engineering BSc major started in 2004 at the Faculty of Informatics at the University of Debrecen. The first revision of this major took place in 2007. Since then there are two compulsory subject in the field of database systems: *Database Systems* and *Database Administration*. An elective subject block is based on these subjects from which the students have to choose one subject compulsorily but they may register further subjects in order to obtain the required credits.

The Software Engineering MSc major started in 2007 at the faculty. The program provides a broad technical understanding of current and evolving technologies in the IT field with an emphasis on moving technology from the laboratory to the realm of business development through its program core courses. In this major, there is only one compulsory subject in the field of database systems: *Data and System Models*. The elective subjects are compulsory in some specializations. In other specializations, students can choose these subjects as elective subjects. In addition to the basic course, there is opportunity to study distributed databases, data warehousing, data mining, database administration, and database security. Laboratory experiences are included in most courses.

In the following, we show the topics all of these subjects as well as some practice materials which can be used during the practice courses throughout the entire curriculum from the first compulsory subject to all of the elective subjects.

2. Subjects in the Field of Database Systems

2.1. Database Systems

Type of subject: compulsory; prerequisite: *Programming Languages 1*; number of lecture and practice hours per week: $2 + 2$; credit: 5.

The main goal of this subject is to present the concept of the three most important basic data models: the relational, the entity-relationship, and the object model. In practice courses, we use the SQL language to manage relational databases.

Lecture topics: Basic concepts: data model, database, DBMS, database system, user groups. The three-schema architecture, data independence. The relational data model. Concepts: domain, attribute, relation schema, tuple, relation. Relational model constraints. Formal query languages for the relational model: relational algebra and relational calculus. Functional dependencies, normal forms and normalization. The Entity-Relationship (ER) model. ER-to-relational mapping. The Enhanced Entity-Relationship (EER) model. EER-to-relational mapping. Concepts for object databases. Overview of the object model of ODMG. The Object Definition Language (ODL). ODL-to-relational mapping. Transaction processing and permission management.

Practice topics: The SELECT statement. WHERE and ORDER BY clauses. SQL functions. Aggregate functions (COUNT, MAX, MIN, SUM, AVG). GROUP BY and HAVING clauses. Joining tables. Inner and outer joins, natural join. Nested queries. Using EXISTS, ALL and ANY. Set operations. Top N analysis. SQL DDL statements (CREATE, ALTER, DROP, TRUNCATE). Further SQL DML statements (INSERT, DELETE, UPDATE, MERGE). The concept of transaction. SQL DCL statements (COMMIT, ROLLBACK, SAVEPOINT). Privileges and roles. Further SQL DCL statements (GRANT, REVOKE). Other database objects (views, sequences, synonyms).

We have created a couple of database schemas that can be used in the practice courses of each subject mentioned in this paper. You can see one of these schemas in Figure 1. These schemas can be used by students to learn all the knowledge related to the subjects described in the previous section.

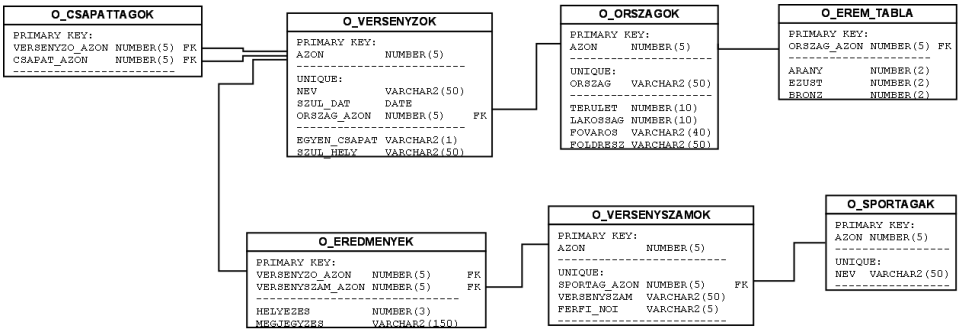

Figure 1: A relational database schema for practice courses.

These schemas can be downloaded from the homepage of *Database Systems*, while test questions regarding these schemas are available on the homepages of the different subjects. In Figure 2, you can see simple questions and answers related to the schema in Figure 1.

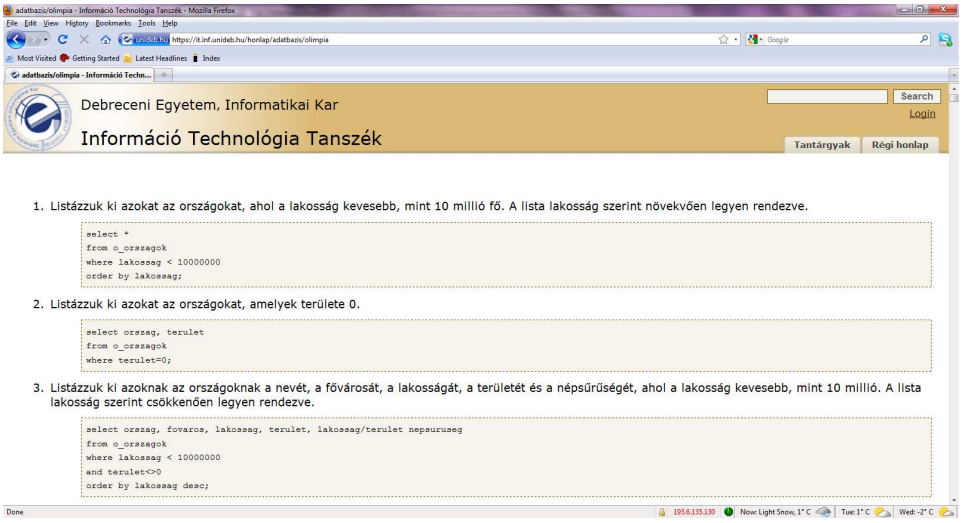

Figure 2: Example queries.

2.2. Database Administration

Type of subject: compulsory; prerequisite: *Database Systems*; number of lecture and practice hours per week: $2 + 0$; credit: 3.

The main goal of this subject is to present the basics of database administration, i.e. the concepts, tasks, and methods used when operating databases.

Topics: The concept of database administrator. DBA tasks. Creating the database environment. Metadata management. Data and storage management. Data movement and distribution. Database security. Database backup and recovery. Disaster planning. Data availability. Performance. Database change management. The topics are discussed in particular DBMSs.

2.3. Database System Implementation 1

Type of subject: elective; prerequisite: *Database Systems*; number of lecture and practice hours per week: $2 + 0$; credit: 3.

The main goal of this subject is to present the algorithms and methods related to logging and concurrency control used by DBMSs in general and Oracle in particular.

Topics: Concept and properties of the transaction. Failure modes. Handling system failures. Logging techniques: undo, redo, undo/redo logging. Archiving. Handling system failures in Oracle database management system. Concurrency control. Schedules and their properties. Conflict-serializability, precedence graphs. Locking systems. Two-phase locking. Various lock modes, compatibility matrices. Lock table. Operation of the locking scheduler. Warning protocol. Tree protocol. Operation of the timestamp-based scheduler. Multiversion timestamping. Operation of the validation-based scheduler. Concurrency control in Oracle. The dirty-data problem. Resolving deadlocks.

2.4. Database System Implementation 2

Type of subject: elective; prerequisite: *Database System Implementation 1*; number of lecture and practice hours per week: $2 + 0$; credit: 3.

The main goal of this subject is to present the algorithms and methods related to query compilation, execution, and SQL tuning used by DBMSs in general and Oracle in particular.

Topics: The query compiler. Syntax analysis and parse trees. The preprocessor. Algebraic laws for improving query plans. Transforming parse trees to logical query plans. Improving logical query plans. Estimating the cost of operations. Cost-based plan selection. Heuristics for reducing the cost of logical query plans. Choosing the order of joins. Join trees. Dynamic programming to select a join order and grouping. Selection of physical query plan. Choosing the method for selection and join. Pipelining and materialization. Ordering of physical operations. The query compiler in Oracle database management system.

2.5. Advanced DBMS Studies 1

Type of subject: elective; prerequisite: *Database Systems*; number of lecture and practice hours per week: $2 + 2$; credit: 5.

This subject combines the declarative SQL with procedural language elements. The lecture and the practice are closely connected. The main goal of this subject is to introduce students to Oracle application development.

Topics: PL/SQL, the procedural language of Oracle. The basic elements of PL/SQL. Data types, conversions. Expressions. Statements, control flow. SQL statements in PL/SQL. The structure of a PL/SQL program. Blocks and subprograms. Scope and life time. Running of a PL/SQL program. Predefined functions. Exception handling. Stored subprograms. Cursors, cursor variables. Packages. Transaction management. Triggers. Testing. The native dynamic SQL. Predefined packages. Optimization. Implementation of applications in PL/SQL.

2.6. Advanced DBMS Studies 2

Type of subject: elective; prerequisite: *Advanced DBMS Studies 1*; number of lecture and practice hours per week: $2 + 2$; credit: 5.

The lecture and the practice are closely connected. The main goal of this subject is to develop the object-relational database application development approach. The student use PL/SQL and Java in the practice courses.

Topics: The object-relational elements of Oracle: collections, object types. The object-relational model of Oracle. Object tables and object views. References. Privileges. Triggers and object-relational features. Management of relationships. Predefined object-relational features. Object-relational modeling. Object-relational applications in PL/SQL. Java and Oracle. Java stored subprograms, JDBC, SQLJ, JSP, EJB. Java and PL/SQL. Java applications in Oracle.

2.7. Data and System Models

Type of subject: compulsory; prerequisite: none; number of lecture and practice hours per week: $2 + 2$; credit: 6.

This subject is a basic subject in the master's program. The main goal of this subject is to give the students a common approach in the field of database systems. The subject summarizes the knowledge about database systems that students had learnt during their previous studies. In the practice courses, students make concrete database schemas using various modeling techniques.

Topics: Abstraction, modeling. Data and function model. Entity-Attribute-Relationship model. Theoretical and practical issues in relational data modeling. Functional dependecies, normal forms, normalization. Data manipulation in the relational model. Relational algebra and relational calculus, SQL, QBE. Semantic and object-oriented models. Nested relational model. ER and EER model. Functional models, the general semantic model. OO and OR models. SQL 2003. ODMG 3.0, ODL, OQL. Mapping the schemas of the various models to each other.

Some theoretical issues and current problems of data modeling. Modeling of information systems (environment, behavior, data and object models). XML as a general model and as a standard communication tool. Web-modeling.

2.8. Database Security

Type of subject: elective; prerequisite: *Data and System Models*; number of lecture and practice hours per week: $0 + 2$; credit: 2.

The main goal of this subject is to present security problems, policies, and standards regarding databases.

Topics: Security and tuning of databases. Managing network communication, services, and remote users. Backup and recovery of databases. Data protection policies and their applications. Automated data management processes. Security objects and policies. DSM, DAC, Mandatory Security Model, Multilevel Secure. Managing integrity. Consistency control.

2.9. Advanced Database Technologies

Type of subject: elective; prerequisite: *Data and System Models*; number of lecture and practice hours per week: $0 + 2$; credit: 2.

The main goal of this subject is to present the concepts of native XML databases. The students use Xquery and Xpath as well as Oracle, eXist, and Sedna DBMSs.

Topics: Native and nested XML databases. XQuery and XForm. Generic architecture for storing XML documents in relational databases. XML based data warehouses. Creating XML based web pages in database environment. Comparing efficiencies. Building portals. Web service development. XML based reusable components. Using OO languages for developing database applications. Application servers. Frameworks.

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